THE REGIONAL MUNICIPALITY OF HAMILTON - WENTWORTH

DEPARTMENT OF ENGINEERING

INFORMATION REPORT ON S.W.A.R.U.

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INFORMATION REPORT

ON

S.W.A.R.U.

I Background

The Regional refuse processing plant, known as S.W.A.R.U. (Solid Waste Reduction Unit), originally owned by the City of Hamilton, was designed in 1968 and 1969 by G. L. Sutin Associates Ltd. The design stage was completed and construction commenced in 1970. In 1972 the plant was finished, at a total cost of $8.95 million. (see Table I)

Being the first plant in the world to employ innovative design features for handling municipal refuse, for example the conveyor feed system and shredded refuse storage tank, numerous operational problems were encountered. As a result of the S.W.A.R.U.'s uniqueness, these problems were new in the field of refuse processing, and required the formulation of original solutions. In 1974, when the Region assumed responsibility for the S.W.A.R.U., it was apparent that few of these problems had been resolved.

The Regional staff were faced with the task of identifying the problem areas and methodically finding solutions.

In brief, twelve areas were identified as being impediments to the productive capacity of the plant. These are:

1. main receiving pit
2. refuse pulverizers
3. shredded refuse conveyors
4. ferrous recovery system
5. Atlas refuse storage tank
6. main fuel (refuse) distributor to boilers
7. individual boiler refuse feeds
8. boiler grate bars
9. combustion air supply (stack emissions)
10. ash removal
11. steam condensers
12. plant instrumentation

Each of these areas were studied and placed in order of priority. The following is a detailed summary which describes capital improvements, modifications, related expenditures and results to date.

TABLE I

SUMMARY OF INITIAL

CAPITAL EXPENDITURES

For Construction of S.W.A.R.U.

(i)	Land costs	$ 150,000.
(ii)	Construction of Plant	8,250,780.
(iii)	Consultants' fees:	
	G. L. Sutin & Associates	500,276.
	Wm. Trow & Associates	45,317.
	TOTAL	$8,946.373.

II Capital Improvements

Figure 1 illustrates the process flow at S.W.A.R.U. and is included as a guide to the following descriptions:

1. Main Receiving Pit

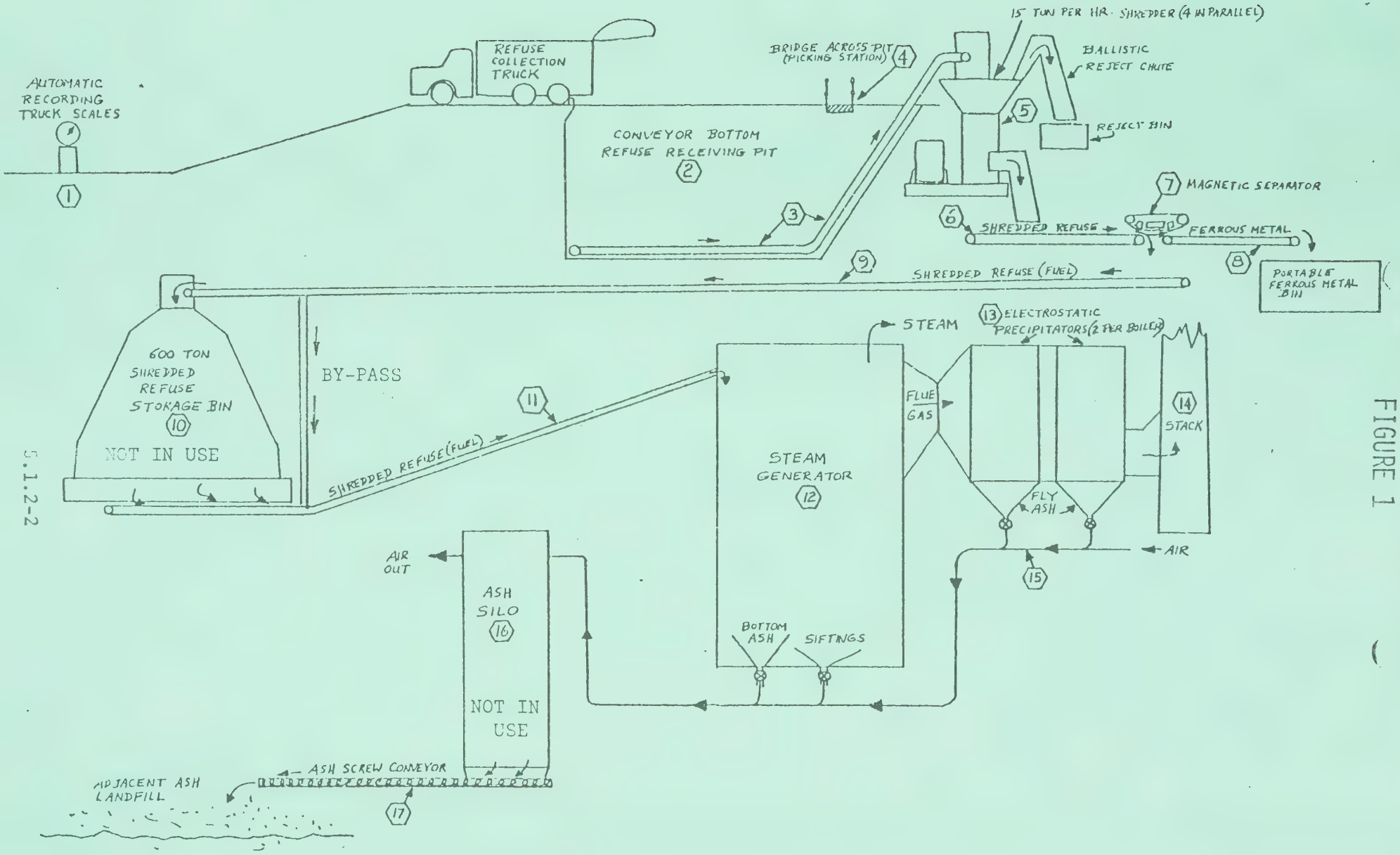
It must have been evident from the time of plant start-up that the 15 H.P. pit conveyor motors were inadequate to give proper performance under design conditions. Frequent stalling of the motors occurred under conditions of partial pit loading, necessitating the use of a crane to dig refuse out of the pit, with accompanying lengthy shut downs. Measures were employed during 1974 and 1975 in an attempt to remedy this problem. These included the installation of shredding knives on the conveyor pans and load-suspending cables in the refuse pit. The original manufacturers were also brought in for consultations. The basic problem was recognized as insufficient conveyor motor power.

In 1976, four replacement 30 H.P. motors, considered the limit for the existing conveyor structure, were installed, and modifications to the drive are being implemented to permit reversal of the conveyors. The total cost of these modifications is $60,000. which is being funded by the Ministry of the Environment $300,000. grant to the S.W.A.R.U. The modifications to permit reversal will be completed by mid May, but with the larger motors already installed, it is apparent that the operating efficiency of the plant has improved. This is evident by comparing the tonnage figures of January and February of 1977 with the same period in 1976. The improvement in throughput for those two months is 3,000 tons.

With present loadings, bridging of the refuse poses a problem, but the significance of this is not yet fully evident. We propose that a new crane be installed over the pit for the purpose of overcoming this bridging problem at an estimated cost of $25,000.

2. Refuse Pulverizers

When the Region took over the S.W.A.R.U. in 1974, the shredder hammers required frequent refacing, resulting in one hour of shredder downtime for every four hours of operation. Every third day, all the hammers had to be replaced due to extensive wear. As a result of trial and investigation, we have now begun to purchase custom



5.1.2-2

FIGURE 1

Figure 5.1.2-1. Schematic process flow diagram of the Hamilton Solid Waste Reduction Unit (SWARU).

made alloy hammers which are more expensive than the previous type ($65. each versus $22.50) but last for 160 hours of operation prior to maintenance, which requires 2½ hours downtime. This has contributed to the overall productivity as evidenced in early 1977. The characteristics of the refuse received still pose a major problem in terms of shredder breakdown. This plant is designed and built to process municipal (ie. typical household) refuse, while the introduction of auto parts, white goods, trees, mattresses, etc. is detrimental to operations and maintenance. The consequence of this type of refuse is to increase downtime and cause blockages in the system. The Department of Streets and Sanitation for the City of Hamilton has agreed to institute a system of selective pickup to overcome these problems, and are in the course of phasing in a modified plan at present which will eliminate 75% of the undesirable items. The original proposal to provide for two special pickups per year was not approved by Board of Control.

3. Shredded Refuse Conveyors from Pulverizers

The housing for the conveyor behind the pulverizers was inadequately designed and suffered continual damage from projectile impact from the shredders. The severity of the damage could not have been anticipated prior to initial operation.

Both the housing and conveyor belt were severaly damaged a number of times, with resulting plant shutdown. After several trial solutions, the problem was rectified temporarily by the use of steel plate curtains, and although the wear has not been eliminated, it has been reduced to the point where routine maintenance is sufficient measure to avoid unscheduled shutdowns.

Additional modifications are necessary for this conveyor housing in the amount of $25,000. in order to reduce maintenance requirements to a reasonable level.

4. Ferrous Recovery System

The original ferrous scrap recovery system was totally inoperative. Prior to the Region's involvement, the firm of M. & T. had a new magnetic retrieval system installed, under a formal agreement with the City of Hamilton.

M. & T. have been purchasing the metal retrieved and

receive a portion of the scrap metal revenue in repayment for their contribution to the system. Out of a total cost of $96,000. for the system, $60,000. was borne outright by M. & T. with the $36,000. balance being retired based on a formula in the agreement. At present, $18,000. is the balance remaining on the original $36,000. debt. In 1976, the magnetic take-away system was modified, as a part of the Atlas by-pass funded by the $300,000. grant from the M.O.E. with an increase in metal recovery of 6.1% in February of 1977 from 3.7% in August of 1976. A figure of 6% to 7% magnetic recovery is generally accepted by solid waste experts as being the maximum obtainable. Revenue from the sale of this scrap was approximately $13,000. in 1976. The original metal take-away conveyor, which deposits recovered scrap in bins, is approaching the end of its service life and should be replaced at a cost of about $30,000. as breakdowns are occurring with increasing frequency.

5. Shredded Refuse Storage (Atlas Tank)

This tank, for the storage of shredded refuse, had deteriorated so badly by 1974 that it became virtually useless shortly thereafter. The principal problem was that of the design concept of the unit. Such a storage system for garbage had never been tried before, anywhere in the world, subsequently the problems that developed were not anticipated. The refuse formed a solidified cone in the centre of the tank and could not be retrieved, causing major setbacks in plant production. Since the Atlas tank could not be made suitably operable, a by-pass system was installed early in 1976 to feed shredded refuse directly to the boilers. This was done at a cost of $108,000. and was funded from the M.O.E. grant. The by-pass served the purpose of providing feed directly to the boilers but this is not a complete solution since we now have no capacity for surge storage nor accommodation of refuse in the event that either the back or front end of the plant is shut down. This increases our dependence on conveyor pit and tipping floor storage capacity, which is only marginally acceptable.

Modifications to the surge storage system were provided for in the 1977 Budget in the amount of $300,000. but have since been deleted in the recent review of the Engineering Budget to reduce the total Budget as requested by the Finance Committee. The Region will pursue the matter of financial aid from the Ontario government.

6. Main Fuel (Refuse) Distributor to Boilers

This unit, which divides the shredded refuse feed to each boiler, did not perform well since plant start-up, and became a source of frequent blockages. Initial modifications to the unit improved matters but after installation of the by-pass the refuse characteristics were altered so drastically, that due to the lack of retention time for the refuse, the main distributor became totally unreliable, plugging constantly and forcing stoppage of plant production. The solution employed required the redesign and replacement of the entire feed distributor unit at a cost of $9,000. We have requested funds from the M.O.E. grant to pay for this work and are optimistic that it will meet with their approval.

This system has proven to be very satisfactory and is again another component contributing to improved plant efficiency.

7. Individual Boiler Refuse Feeds

The feeds (or downchutes) one set per boiler, had experienced problems identical to those in the main distributor (Item #6). In October of 1976, the downchute on boiler #1 was replaced with a redesigned unit and its performance met our expectations. Following this trial, the new unit for boiler #2 was built and has just been installed. These modified feeds cost a total of $10,200. and funding has been requested from the M.O.E. Both sets of downchutes are performing exactly as planned, and have done their part to improve the productivity of the S.W.A.R.U. by reducing downtime intervals, maintenance costs and standby manual labour.

8. Boiler Grates

The boilers (Babcock & Wilcox) in the system have proven to be two of the most dependable components at S.W.A.R.U. However, occasional breakage of grate bars occurs as a result of the nature of the "fuel" being burned. This problem is not a top priority but warrants investigation in the near future.

9. Combustion Air Supply

Stack emissions have been the subject of criticism at intervals. It has been determined, in conjunction with Babcock & Wilcox staff, that an inadequate combustion air supply in the boilers has contributed to sporadically unacceptable smoke and soot emissions. Internal ash congestion in the electrostatic precipitators was initially thought to cause this problem. However, the true source of trouble lies in the inadequate air supply. Departmental staff, in conjunction with Babcock & Wilcox personnel,

have arrived at a plan for modifications to the air supply which will improve matters. An "auxiliary overfire air system" is proposed which will reduce stack emissions and provide the extra air necessary to burn a full loading of shredded refuse. Problems caused by unburned particles within the boilers and precipitators will subsequently be eliminated. Over the years the accumulation of these particles in the precipitators has finally necessitated the replacement of one bank of precipitator plates. This work will be carried out in 1977 at an estimated cost of $30,000. The estimated cost of the entire modified overfire air system is $70,000. and the fans, comprising $18,000. of this sum have already been purchased. We have requested funding for the auxiliary overfire air system from the M.O.E. grant, however, the balance of the grant is insufficient to cover the cost of the precipitator overhaul. These latter funds have therefore been requested in the current budget.

One further advantage to the overfire air modification is that, since the auxiliary system will be electrically operated, the boilers can then be started up on shredded refuse, rather than having to burn natural gas to build up the boiler steam in order to run the present steam turbine fans. It is certain that, along with improved stack emissions, the fuel costs will decrease and production will improve.

10. Ash Removal System

The pneumatic ash take-away system, including storage silo, was designed to remove the bottom ash from the boilers and fly ash from the precipitators. The nature of these two ashes combined with contamination from light metalics such as tin cans and springs, rendered the system inoperable and all efforts to make it work failed; the plant could not operate without ash removal. The S.W.A.R.U. staff field-constructed individual take-aways for both ash systems in 1973, arriving at the present mechanisms in 1976 which adequately perform the needed function. This present system is not ideal because the conveyor area is always dirty, and the abrasive nature of the ash requires continual maintenance monitoring. However, this system is satisfactory at present and is not detrimental to plant operations. When the more serious restraints on plant capacity are resolved, the ash removal system must again be reviewed to make it completely environmentally acceptable.

11. Steam Condensers

The rooftop condensers are designed to remove combustion

heat from boiler steam in order that the steam system water can be recycled for boiler wall cooling. All eight condenser units began leaking during the first year of plant operation and the situation worsened progressively. The most recent severe leakage has posed a danger of structural collapse to the roof of the main building during the last two winters, as a result of ice build up on the roof. Leakage in hot weather curtails plant processing capacity because the most seriously damaged condensers must be isolated from the system; the steam cannot be condensed for recycling and an inordinate amount of make-up water must be provided to the boilers due to leakage; in fact, the make-up system also has limits. This has caused repercussions in other parts of the system.

Increased water demands result in greater expense for water conditioning chemicals. In addition, the impurities in the water collect at such a rapid rate that constant vigilance is necessary to avoid sludge blockage in boiler tubes. Left unchecked, tube blockages would quickly lead to costly burnouts. The L. H. Schwindt Company of consulting engineers has been hired at a cost of $8,000. to investigate the problem, and their report has been reviewed and accepted. Included in this cost for service is the preparation of drawings and specifications necessary to remedy the condenser problem. Plans are now being prepared. Estimated costs for modifications and repairs to the condenser system are approximately $200,000.

At a future date, if S.W.A.R.U. can guarantee a reliable steam supply, we can investigate the market potential for the sale of steam. At that time, all the condensers would not necessarily have to be operable. However, installation of a steam line would cost about $300. per foot and it is best to reserve judgment on such a scheme at present.

12. Plant Instrumentation

All of the instrumentation essential to the everyday operation of the plant is functional. Some of the more exotic instruments, such as those weighing the refuse into each boiler, have never worked and their usefulness is questionable.

Generally, the degree of accuracy being encountered in the instruments currently in use is not critical at this time except for emission control and monitoring. A suitable maintenance contract is being negotiated with Bailey Metering, the original instrument suppliers, in order to bring all of these units up to standard and

satisfy the Ministry of the Environment's air standards. Such a contract will cost from $5,000. to $10,000. per year.

III Provincial Assistance

In 1976 the Region was awarded a grant from the Ministry of the Environment in the amount of $300,000. This money was allocated for improvements as detailed in Appendix A, to increase plant operating efficiency.

IV Plant Efficiency

1. Design versus Working Capacity

The S.W.A.R.U. operating efficiency has always been expressed as a percentage of the plant's design capacity designated as 600 tons per day. The limiting factor in the system is the maximum operating capacity of the two boilers which are each rated at 300 tons per day for a total possible production of 600 tons per day. The annual design capacity rating for the plant, namely 219,000 tons, assumes that the boilers can operate continuously, 24 hours per day, 365 days per year without interruption.

The plant operating efficiency figure of 22.7 per cent for the year 1976 (see Appendix B) was based on the design capacity. We are of the opinion that the operating efficiency should be related to a more meaningful capacity figure, namely that of "working capacity". This figure represents the average tonnage which can be efficiently processed through this plant for 365 days in the year, allowing for necessary maintenance shutdowns, unforseen minor breakdowns which must be expected during operations, and variability of the supply of refuse material during periods of inclement weather. We project this working capacity to be approximately 450 tons per day or approximately 165,000 tons per year (75% of maximum theoretical design capacity).

Based on this premise, our annual working efficiency for 1976 was in the order of 30%, (ref. Appendix D).

2. Personnel Problems

An additional factor affecting the S.W.A.R.U. efficiency is related to plant personnel. Although this problem is not in quite the same category as design or mechanical inadequacies, it has nonetheless significantly affected plant operations. The level of staffing has fluctuated from a low of 36% and has never reached a 100% complement. The absentee rate has always been extremely high, even in view of stricter requirements for medical certificates of illness after the first day's absence. We believe that this situation arises as a result of typical working conditions at a garbage processing facility, for which there appears to be no immediate solution. The plant staff organization totals 51 and is arranged as follows:

V Current Operating Costs and Debt Charges

A detailed analysis of costs associated with the S.W.A.R.U. operation is presented in Appendix C, S.W.A.R.U. Cost-Performance Summary: 1973 to 1976.

The 1973 total annual operating costs were $53.12 per ton of waste processed; of this, $27.81 per ton represented the actual plant operating and maintenance costs and $25.31 per ton represented the debenture charges. In 1976 the total annual operating costs were $48.51 per ton of waste of which $30.46 per ton represented the actual plant operating and maintenance costs and $18.05 per ton represented the debenture charges. As noted in Appendix E, debenture charges are currently in the order of $900,000. and the debt will be fully amortized in 1994. It should also be pointed out that the largest single item of operating and maintenance expense is the repayment of debt. Appendix F details the balance of interest and principal payments until the end of the amortization period. The total of these debenture charges between 1977 and 1994 amount to $12,577,016.55.

VI Future Capital Expenditures

The original capital cost of the S.W.A.R.U. when completed in mid 1972 was $8.95 million. If an identical facility were to be placed in operation in early 1977, the capital cost would have escalated by a factor of 1.6 to about $14,000,000.

The proposed additional capital costs required to achieve a projected full working capacity of 165,000 tons per year (450 tons per day) are summarized below:

a)	Refuse Storage - modify storage facilities	$300,000.
b)	Steam Condensers - repair and correct deficiencies	200,000.
c)	Central Dust Control System - vacuum collection system to upgrade plant working environment	150,000.
d)	Ash Removal System - improvements necessary to handle waste ash from plant	120,000.
e)	Precipitators - plate replacement and instrumentation .	50,000.
f)	Ferrous Recovery System - overhaul metal take-away conveyor and install air classifier	30,000.
g)	Shredded Refuse Conveyor From Pulverizers - modify housing	25,000.
h)	Main Receiving Pit - install larger bridge breaker device ..	25,000.
	SUB TOTAL	900,000.
	Contingency	100,000.
	Total of Additional Capital Requirements	$1,000,000.

VII Summary

(i) Modifications are still taking place at S.W.A.R.U. and the high cost per ton figures are to be expected at this time. Plants of this type are highly capital intensive and the amount of waste material that can be processed is the real determining factor of success.

Based upon improvements effected in 1976, Regional staff project a 1977 figure of 100,000 tons of waste processed. If this goal is met, at a budgeted total of $2.5 million for 1977, the total annual operating cost of the plant will be reduced to approximately $25.00 per ton. Implementation of the proposed capital improvements in the amount of $1 million, will enable us to achieve a working capacity of 165,000 tons per year (450 tons per day). The total of the operating, maintenance and debenture charges associated with this throughput are estimated to be in the area of $16.00 per ton of refuse processed.

(ii) The S.W.A.R.U. was developed with the intent that the surplus steam produced would be sold for revenue. However, the project proceeded without any specific steam customers. To date, there has been no attempt to sell steam and no distribution system exists. Until the plant performance is upgraded and a constant steam supply can be assured, potential clients cannot be attracted.

(iii) It should be pointed out that one of the "Solid Waste Management Proposal" bidders, namely Tricil Ltd., has in its submission offered to guarantee the processing of a minimum of 120,000 tons of waste per year through S.W.A.R.U. along with a request for a negotiated bonus award for each ton over 150,000 tons. This proposal of Tricil Ltd. is still subject to review by the Region along with five other firms.

(iv) In comparison to landfill methods of disposal, S.W.A.R.U. represents a costly alternative at present. Nonetheless, it is significant that we realize that S.W.A.R.U. processed approximately 40% of the total municipal waste from the City of Hamilton. The cumulative effect of this service has, over the last three years, assisted substantially in extending the remaining life of our landfill sites, which are rapidly reaching their final capacity. Studies have revealed that, under present circumstances, all

Regional landfill site capacity will expire in 1979; it is therefore essential that further disposal facilities are provided. The monetary value of this reprieve assistance, although intangible, must also be weighed in assessing the S.W.A.R.U. operating costs.

(v) The Ralph M. Parsons Co. of California who were commissioned recently by the Environmental Protection Agency of the United States to review and report on various types of solid waste processing plants in the United States and Canada, made the following comments in their reports on S.W.A.R.U. and we quote:

"Most of the faults and problems are susceptible to correction and this facility may yet become an efficient refuse-to-energy operation".

"It is unlikely that another plant would be built today to this same design; however, it is believed that improvements in shredding, materials handling, shredded waste storage, ash handling and dust control could all be realized for about one million dollars. These changes, though quite costly, would so drastically improve the operation as to pay for themselves in a short time".

From the studies and work carried out by the Region in the last three years, it is our considered opinion that S.W.A.R.U. can be made to function and can reach a working capacity of 450 tons per day. In order to attain an ultimate capacity of 600 tons per day, major modifications and additions must be carried out.

I am referring to the possibility of an additional furnace unit and perhaps the complete reconstruction of the front end tipping floor and pit.

Additional shredders may also have to be provided. These, however, will involve future studies both technological and economical. It has been our philosophy in our approach to S.W.A.R.U. that we should attempt to solve the problems without radically changing the design concept of S.W.A.R.U. and spending large capital sums.

It would appear that this approach is bearing fruit and we are on the verge of success. It may appear to many that our progress has been extremely slow but in a facility such as this, there is no quick answer or solution to the problems. These problems can only be solved on a trial and error basis.

Regardless of the publicity being given to the various approaches to solid waste management and waste recovery systems, there are none in North America that are beyond the experimental or research stage. In fact, in the last several months, many of the highly touted projects in the United States have been abandoned because of lack of technology and/or funds.

In Hamilton-Wentworth, we are ahead of any other municipality in North America in that we do have a plant which is on the verge of reaching an acceptable throughput, and at an estimated reasonable cost.

I trust that the Committee will bear with us in our efforts to make S.W.A.R.U. a success, because I can assure you that no one wishes it to succeed more than we do.

VIII. UPDATE INFORMATION REPORT ON S.W.A.R.U.

(Supplement to Report Dated April 1977)

February 1978

UPDATE INFORMATION REPORT ON S.W.A.R.U.

(Supplement to Report Dated April 1977)

A. INTRODUCTION

This report serves to update the information presented in "Information Report on S.W.A.R.U." dated April 1977 which was prepared by the Department of Engineering of the Regional Municipality of Hamilton-Wentworth.

B. PERFORMANCE OF PLANT IN 1977

a) The quantity of refuse processed at S.W.A.R.U. in 1977 was 56,511 tons with a total expenditure of $2,823,000 for the year. Total annual operating costs were $55.90 per ton of waste of which $37.90 per ton represented the actual plant operating and maintenance costs and $18.00 per ton represents the debenture charges.

b) The revenue for recovered metals amounted to $43,000.

c) The balance of the Provincial 1976 grant of $300,000 was spent on various plant repairs and modifications to improve the plant's processing functions and to reduce the environmental impact resulting from operations. All expenditures were carried out with the prior approval of Ministry of Environment staff.

d) A major fire occurred in the plant on the conveyor belts on June 24, 1977, with damage in the amount of $145,000. Plant processing did not resume until August 15, 1977. This unfortunate fire reduced the production figures originally planned for 1977. The fire underwriters were deeply concerned

B. PERFORMANCE OF PLANT IN 1977

4) Cont'd.....

about this fire damage and as a result a fire protection proposal was developed by the Region and the insurance company at an estimated cost of $235,000. A contract has already been awarded by Regional Council to the firm of Adam Clark, with work to commence this month.

5) Leaking steam condensers were overhauled at a contract cost of $235,000.

6) Precipitators were overhauled at a cost of $40,000 to improve emissions. One complete electrostatic field was replaced.

7) In October, 1977, Regional Council awarded a contract to Tricil Ltd. for the construction and operation of a solid waste management system. This full service contract included the operation and management of S.W.A.R.U. with a guarantee to process a minimum of 120,000 tons of waste per year along with a bonus award for each ton over 150,000 tons. Tentatively, it is proposed for the contractor to assume S.W.A.R.U. responsibilities on February 15, 1978 pending approval of the basic agreement by Regional Council on February 7, 1978. Additional resource recovery operations will be reviewed periodically and implemented when technology and economics permit.

B. PERFORMANCE OF PLANT IN 1977

7) Cont'd.....

Repairs and improvements in the amount of $568,500 are required as part of the assumption procedures. These items are detailed further in this report. The major costs are related to the boilers, precipitators, and condensers.

C. CAPITAL EXPENDITURES CARRIED OUT IN 1977 BY REGION

WORK COMPLETED DURING 1977

1)	Steam Condenser: Rebuilding	$235,000.
2)	Fly Ash Removal System: Wet Ash Take-away	$ 25,000.
3)	Precipitator - Outlet Field Replacement	$ 40,000.
4)	Metal Take-away System Improvements	$ 6,000.
5)	Shredded Refuse Conveyor from Pulverizer #4 - Modify Feed Chute	$ 2,000.
6)	Security Fence	$ 3,500.
	Section C Total	$311,500.

AMENDMENT TO SECTION "D" ON PAGE 22 (AS OF 4 APRIL 1978)

Since the month of February, the Department of Engineering, in liaison with Tricil Ltd., has carried out a review of the S.W.A.R.U. plant equipment, which required repairs as per Schedule "C" of the agreement between the Region and Tricil Ltd., dated 15 February 1978.

This schedule provided for certain works and services which must be fully completed by the Region, prior to Tricil Ltd. assuming full responsibility for the S.W.A.R.U.

This review has revealed additional work areas requiring renovation which previously could not be identified. These added items are shown in the revised list below and are marked with the symbol *.

D. CAPITAL EXPENDITURES REQUIRED FOR TRICIL ASSUMPTION IN 1978

	1.	Fire Protection System	$235,000
	2.	Condenser Preheating System	158,000
*	3.	Plant Turbine Room - repair roof	2,000
	4.	Exit Ramp Repairs	20,000
	5.	Finish Ash Disposal Site	10,000
	6.	Roadway Repairs	17,000
	7.	Boiler Inspection and Repairs	170,000
	8.	Precipitator Renovations	20,000
*	9.	Restoration of Hydraulic System	45,000
*	10.	Install Hydraulic Fluid Filter System	15,000
*	11.	Install New Steam and Condensate Valves	30,000
*	12.	Install Condensate Alarms	5,000
*	13.	Restore Plant Instrumentation	10,000
*	14.	Winterize Wet Ash Removal System	7,000
*	15.	General Plant Repairs	6,000
		REVISED TOTAL	$750,000

E. FUTURE CAPITAL EXPENDITURES REQUIRED

1)	Refuse Storage Tank	$650,000.
2)	Central Dust Collection System	165,000.
3)	Ash Removal System Improvements	40,000.
4)	Metal Recovery System - Air Classification	25,000.
5)	Receiving Pit - bridge breaker crane	30,000.
6)	Shredded Refuse Conveyor - Modify Pulverizer Chutes	15,000.
		$925,000.
	Contingency	75,000.
	Section E Total	$1,000,000.

F. SUMMARY

It is interesting to note that the Region of Hamilton-Wentworth has now retained private enterprise as an experienced waste processing partner in its efforts to resolve the remaining design problems within the S.W.A.R.U. and to gain and maintain working capacity production (165,000 tons/year).

The proposal and guarantee offered by Tricil Ltd. (120,000 tons/year) is a vote of confidence to the previous efforts of the Region and is further indicative that we are very close to achieving success.

We are of the opinion that this alliance, supported by the availability of financial support indicated above, will overcome the present technical and economic barriers and ultimately establish this facility as an efficient refuse-to-energy operation.

APPENDIX "A"

APPENDIX A

S.W.A.R.U. Expenditure

Pertaining to

1976 Grant from the

Ministry of the Environment

SECTION A: Tabulated Summary of Works and Expenses

Part I

Work that has been approved by the Ministry of the Environment

Item		Cost
1.	Pit conveyor modifications	
	(a) supply & install one 25 H.P. motor and three 30 H.P. motors, complete with heavy duty controls; (complete) (approved 30 July 1976)	$ 52,000.00
2.	Atlas tank by-pass (complete) (approved 30 July 1976)	$ 107,544.00
3.	Boiler room modifications (complete) (approved 30 July 1976)	$ 4,576.00
4.	Industrial sweeper (work in progress, i.e. tendered) (approved in principle 14 December 1976)	$ 15,000.00
5.	Supply & Install overfire air fans complete with ducting - estimate (planning in progress) (approved 8 February 1977)	$ 30,000.00
	Sub-Total Part I	$ 209,120.00

Part II

Work for which reimbursement is requested from remainder of grant.

Item			Cost
1.	Alterations required to fit three 30 H.P. pit conveyor motors to drives. (complete)		$ 6,000.00
2.	Pit conveyor hold-down retaining angles, work associated with pit motor change - estimate (work in progress)		$ 10,000.00
3.	Modifications to boiler feed system (complete)		
	boiler # 1 feed distributor	$ 4,459.60	
	boiler # 2 feed distributor	$ 5,663.60	
	main feed splitter	$ 8,757.38	
		$18,880.58	$ 18,880.00
4.	Modify metal separator system in transfer room (complete)		$ 4,256.00
5.	Supplementary power feed for overfire air fans, Part I, item 5. - estimate (planning in progress)		$ 15,000.00
6.	Overfire air piping, injection nozzles - estimate (planning in progress)		$ 40,000.00
7.	Automatic gas start-up system complete with recalibration of instrumentation - estimate (work in progress)		$ 7,000.00
8.	Safety pull cords and switches (work in progress)		$ 2,480.00
	Sub-Total Part II		$ 103,616.00
	Totals Part I and II		$ 209,120.00
			$ 103,616.00
			$ 312,736.00

APPENDIX "B"

APPENDIX B

SUMMARY OF THE OPERATION OF S.W.A.R.U. IN 1976

1976	TOTAL REFUSE PROCESSED Tons	Operating Efficiency	REFUSE PROCESSED FROM STONEY CREEK Tons	%	** GAS X10^3 CU. FT.	*** STEAM X10^3 LB.	METAL Tons	%	REFUSE (TONS) Scrap	Other	%	LABOUR HOURS Worked	Lost	O / T	% ABSENCE
Jan.	1,585	8.0	34	2.1	7,008	10,258	48	2.5	NIL	9	0.4	7,137	448	480	6.3
Feb.	4,043	25.0	237	5.8	4,997	20,780	151	3.8	9	24	0.7	7,088	574	433	8.1
Mar.	4,983	26.7	379	7.6	5,389	21,298	212	4.3	9	24	0.7	7,426	1,057	538	14.1
Apr.	5,064	27.2	303	5.9	4,083	22,920	176	3.5	16	39	1.1	7,242	646	432	9.1
May	5,059	27.1	372	7.3	2,425	25,722	170	3.4	17	48	1.3	7,569	696	527	9.2
June	2,686	14.9	56	2.0	2,683	11,941	73	2.7	12	33	1.7	7,432	632	388	8.5
July	4,738	25.4	198	4.1	4,326	29,727	166	3.5	12	28	0.8	6,770	848	538	12.5
Aug.	4,940	26.5	161	3.2	4,928	30,753	195	3.9	12	24	0.7	6,536	1,880	539	(28.7)
Sept.	2,126	11.8	128	6.0	1,985	18,353	81	3.8	12	24	1.7	6,523	764	237	11.7
Oct.	4,237	23.5	255	6.0	2,818	30,866	165	3.9	6	42	1.1	7,720	879	880	11.4
Nov.	5,166	28.7	358	6.9	4,368	33,635	179	3.5	8	36	0.9	7,700	904	442	12.3
Dec.	5,242	28.1	507	9.6	4,917	44,479	225	4.3	4	39	0.8	7,149	1,080	702	18.0
TOTAL	49,869	22.7 *	2,988	5.9	51,927	300,732	1,841	3.7	117	370	1.0	85,992	10,408	6,130	12.7

NOTES

( ) Vacation period.

* This figure is based on an ultimate design capacity of 600 TPD, on a 24 hour day, 365 days per year operating basis.

** Natural gas is needed to fire the boilers to maintain operating steam pressure when refuse is not being burned.

*** Approximately 40 percent of the steam produced is needed for heating, and operating turbine powered equipment, when the plant is operating at full capacity.

APPENDIX "C"

APPENDIX C

SWARU COST-PERFORMANCE SUMMARY 1973-1976

Year	1973	1974	1975	1976
Cost of Plant Operations	$674,738	$918,430	$1,218,696	$1,518,841
Debenture Charges	$614,100	$905,821	$904,277	$900,433
Total Annual Operating and Maintenance Costs	$1,288,838	$1,824,251	$2,122,973	$2,419,274
Refuse Processed in Tons	24,265	38,955	48,117	49,869
Cost of Plant Operations $/Ton	27.81	23.58	25.33	30.46
Debenture Charges $/Ton	25.31	23.25	18.79	18.05
Total Annual Costs $/Ton	53.12	46.83	44.12	48.51

APPENDIX "D"

APPENDIX D

SWARU TONNAGE RECORD - 1974 to 1976

	1974			1975			1976		
	TONS	% OPERATIONAL EFFICIENCY D.C.*	W.C.**	TONS	% OPERATIONAL EFFICIENCY D.C.*	W.C.**	TONS	% OPERATIONAL EFFICIENCY D.C.*	W.C.**
January	1212	6.5	8.7	5084	27.3	36.4	1585	8.0	10.7
February	3616	21.5	28.7	3405	20.2	27.0	4043	25.0	33.3
March	3056	16.4	21.9	4976	26.7	35.6	4983	26.7	35.6
April	4161	23.1	30.8	1512	8.4	11.2	5064	27.2	36.3
May	4931	26.5	35.3	5274	28.3	37.8	5059	27.1	36.1
June	3355	18.6	24.8	2086	11.5	15.4	2686	14.9	19.9
July	3276	17.6	23.5	3237	17.4	23.2	4738	25.4	33.9
August	2846	15.3	20.4	4626	24.8	33.1	4940	26.5	35.3
September	3659	19.6	26.2	5611	30.1	40.2	2126	11.8	15.7
October	3533	18.9	25.3	5263	28.2	37.7	4237	23.5	31.3
November	2221	12.3	16.4	3652	20.2	27.0	5166	28.7	38.2
December	3089	16.6	22.1	3391	18.2	24.3	5242	28.1	37.5
	38,955	17.7	23.7	48,117	21.9	29.2	49,869	22.7	30.3

* This figure is based on an ultimate design capacity of 600 TPD, on a 24 hour day, number of days per month operating basis.

** This figure is based on a practical working capacity of 450 TPD, on a 24 hour day, number of days per month operating basis.

APPENDIX "E"

ECONOMIC EVALUATION - 1974 to 1976

	1974	1975	1976
Debenture Debt *	$905,821	$904,277	$900,433
Salaries	$458,700	$605,000	$766,049
Equipment and Maintenance	$279,200	$374,000	$449,348
Fuel	$ 86,300	$203,000+	$151,120
Utilities	$ 48,000		$ 85,230
Other	$ 46,230	$ 36,696	$ 67,094
	$1,824,251	$2,122,973	$2,419,274

+ Fuel and Utilities are combined.

* Debenture Debt will be fully amortized in 1994.

APPENDIX E

APPENDIX "F"

APPENDIX F

S.W.A.R.U. ANNUAL DEBENTURES

	PRINCIPAL	INTEREST	TOTAL ANNUAL PAYMENT
77	315,123.35	591,954.72	907,078.07
78	337,193.36	567,510.01	904,703.37
79	370,446.72	541,318.33	911,765.05
80	395,516.71	512,410.21	907,926.92
81	421,596.71	481,524.52	903,121.23
82	444,356.71	448,565.65	892,922.36
83	386,586.71	415,485.61	802,072.32
84	420,666.71	382,245.42	802,912.13
85	450,666.71	345,865.21	796,531.92
86	484,666.71	306,850.64	791,517.35
87	530,666.71	264,940.42	795,607.13
88	580,000.00	219,031.25	799,031.25
89	632,000.00	168,865.63	800,865.63
90	687,000.00	114,163.12	801,163.12
91	252,000.00	54,704.37	306,704.37
92	231,000.00	33,369.38	264,369.33
93	175,000.00	13,725.00	188,725.00

Balance of Interest and Principal Charges From 1977 to 1994 $12,577,016.55

APPENDIX "G"

APPENDIX G

MODIFICATIONS PERFORMED AT S.W.A.R.U.

SINCE 1973

The works detailed in this appendix were carried out directly by S.W.A.R.U. personnel, or under their direction, in order to resolve various conceptual and operating problems that became apparent after plant start-up. These modifications were funded from the annual operating budget and are exclusive of any capital improvements covered under the 1976 grant from the Ontario Ministry of the Environment for $300,000 (Ref. Appendix A).

The cost figures indicated are the most accurate available in view of the difficulty of tracing all past timesheets and invoice details.

1. PIT CONVEYORS

	Modifications	Year	Cost
(i)	Alterations to conveyor in an attempt to reduce the load on the electric motors and reduce bridging	1973 1974	$ 5,500
(ii)	Construct and install hook for pit crane to break refuse bridges	1973 1974	$ 2,000
(iii)	Alter pit bridge deck	1973	$ 1,200
(iv)	Install lubrication system	1973	$ 1,800
(v)	Install clean-up hoist system	1974 1976	$ 5,000
(vi)	Alter drive shear pin arrangement	1974 1977	$ 800
(vii)	Install pit cables to alleviate conveyor loading	1976	$ 4,600
(viii)	Install conveyor speed control on bridge	1976	$ 2,500
SUB-TOTAL 1			$23,400

2. PULVERIZERS

	Modifications	Year	Cost
(i)	Trial operations and outfitting pulverizers with hard faced hammers and liners. Change hammer materials and configuration. Change liner materials and configuration. Change neck ring materials and configuration.	1973 1974 1975 1976	$ 8,500
(ii)	Fabricate and install electric motor air filters	1974	$ 2,000
(iii)	Install cleanup hoppers	1974	$ 6,000
(iv)	Fabricate and install low oil warning system	1975	$ 5,000
(v)	Alter shaft oil seal	1975 1976	$ 6,000
SUB-TOTAL 2			$27,500

3. CONVEYORS

(i)	No. 5 conveyor: alterations to baffles for pulverizers	1973 1974 1975	$ 6,000
(ii)	No. 6 and 7 conveyors: install wind proof skirts	1974	$10,000
(iii)	No. 6 conveyor: change location and increase power of drive motor; alterations to tail pulley and idlers	1975	$ 2,500
(iv)	No. 7 conveyor: install clean up pan and relocate head pulley	1975	$ 1,500
(v)	No. 8 and 9 conveyors: alter discharge chutes	1974 1975 1976	$ 3,000
SUB-TOTAL 3			$23,000

4. METAL RECOVERY SYSTEM

	Modifications	Year	Cost
(i)	Alterations to magnetic separator: $60,000 from M. & T.		
	Balance (City and Region)	1975	$36,000
(ii)	Belt scrapers	1973 1974 1975 1976	$ 3,800
(iii)	Metal container alterations	1975	$ 2,200
(iv)	Alterations to completed by-pass	1976	$ 4,500
SUB-TOTAL 4			$46,500

5. Shredded Refuse Storage (Atlas Tank)

	Modifications	Year	Cost
(i)	Install steam syphon for sump water removal	1973	$500
(ii)	Alter drive clutches control, operate two turbines on sweep drive	1973 1974	$6,000
(iii)	Alter sweep buckets, pins and links	1973 1974 1975	$10,000
(iv)	Alter tank wall and fabricate boom extension, removing bord refuse core	1974	$6,000
(v)	Install lighting	1974	$2,500
(vi)	Install shear pins in sweep drives	1974	$6,000
(vii)	Alter outfeed trench	1974 1975	$5,000
(viii)	Alter outfeed conveyor	1974 1975	$1,000
(ix)	Alter head pulley box & chute	1974	$4,000
(x)	Install distributor from No. 6 conveyor	1974 1975	$3,500
Sub-Total 5			$44,500

6. Boilers

(i)	Alter vacuum ash system	1973	$6,500
(ii)	Remove air seal valves in cinder return	1973	$3,000
(iii)	Alter air seals in boiler furnace	1973	$1,000
(iv)	Install catwalks to valves, T.V., splitter	1973	$4,000
(v)	Alter level control on condensate receiver	1974	$2,500
(vi)	Install loop seal for deaerator and condensate receiver	1974	$1,400
(vii)	Install hoist way to basement	1974	$2,500
(viii)	Install instrument enclosure	1974	$1,200

	Modifications	Year	Cost
(ix)	Cover floor gratings with checker plates	1974	$2,000
(x)	Modify grate drive control for boiler furnace	1974	$1,800
(xi)	Modify hoppers for cinder return	1974	$4,000
(xii)	Install precipitator screw conveyors	1974	$20,000
(xiii)	Install bottom ash vibrators and hopper	1974	$58,000
(xiv)	Rental of bottom ash conveyors	1974	$11,000
(xv)	Install bottom ash conveyor belt	1975	$16,000
(xvi)	Modify precipitator vibrators and hoppers	1975	$3,800
(xvii)	Modify precipitator conveyor hopper outlet	1975	$5,000
(xviii)	Install steam jets on cinder return	1975	$7,500
(xix)	Alter refuse fuel burners in furnace	1975	$6,000
(xx)	Fabricate and install precipitator wet ash system	1976 1977	$11,000
(xxi)	Install pit conveyor speed control	1976	$1,900
(xxii)	Alter surplus steam system control	1975 1976	$10,000
(xxiii)	Relocate closed circuit T.V.	1976 1977	$4,000
(xxiv)	Install platforms for stack tests	1976	$4,500
(xxv)	Modify water softener control systems	1976	$4,500
(xxvi)	Install exterior wall for wind protection	1977	$3,000
Sub-Total 6			$196,100

7. Steam Condensers

(i)	Install catwalks to valves	1973	$4,600
(ii)	Alterations to low pressure relief valves	1973	$3,800
(iii)	Install vacuum breaker valves	1973	$1,700
(iv)	Modify condensate drain system	1973	$4,200
(v)	Alter fan motors installed in reverse	1973	$5,000

	Modifications	Year	Cost
(vi)	Modify hydraulic relief valves	1974	$ 1,500
(vii)	Install condenser drain valves	1974	$ 1,800
(viii)	Install additional hangers and bracing on hydraulic piping	1974 1975 1976	$ 8,000
(ix)	Install mechanical seals on hydraulic pumps	1976 1977	$ 1,100
SUB-TOTAL 7			$31,700

8. Compressed Air System

(i)	Install air after-cooler	1973	$10,000
(ii)	Install air drier	1974	$12,000
(iii)	Install No. 4 air compressor	1975	$20,500
SUB-TOTAL 8			$42,500

9. Plant General

(i)	Modify sewer piping hangers	1973 1974 1975	$ 1,500
(ii)	Install cover for gas meter and valves	1975	$ 500
(iii)	Purchase rubber-tired loader for tipping floor	1976	$30,000
(iv)	Purchase isolation steam valves	1976	$ 3,000
(v)	Alter crane electrical to pit bridge deck	1977	$ 2,300
(vi)	Install fence around exposed mechanical portion of plant	1977	$15,100
SUB-TOTAL 9			$52,400

SUB-TOTAL 1	$23,400
SUB-TOTAL 2	27,500
SUB-TOTAL 3	23,000
SUB-TOTAL 4	46,500
SUB-TOTAL 5	44,500
SUB-TOTAL 6	196,100
SUB-TOTAL 7	31,700
SUB-TOTAL 8	42,500
SUB-TOTAL 9	52,400

Total of SWARU Capital Improvements funded by City of Hamilton and Region from 1973 to present	$487,600

APPENDIX "H"

APPENDIX H

SUMMARY OF S.W.A.R.U. COSTS IN

YEAR OF COMPLETION: 1972

Debenture Debt	$ 639,656.00
Salaries	$ 250,455.00
Equipment and Maintenance	$ 51,216.00
Fuel	$ 110,934.00
Utilities	$ 32,348.00
Other	$ 25,811.00
TOTAL	$1,110,420.00

Tonnage records for 1972 are not available because the plant was still in its trial period.